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REDD+ adoption and factors affecting respondents' knowledge of REDD+ goal: Evidence from household survey of forest users from REDD+ piloting sites in Nepal☆

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ABSTRACT

Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD+) has been piloted in several countries among socio-economically diverse forest-dependent communities and households. Piloting is a way to raise awareness of REDD+ and its likely practice in the future. The impacts of piloting schemes on likely adoption of REDD+ among participating households and whether those households are fully aware of REDD+ goal are not fully understood in a range of contexts. This paper examines the likely adoption of REDD+ in community forests and factors affecting respondent's knowledge of REDD+ goal using post-piloting survey of 600 households from two watersheds in Nepal. Controlling for respondent, household, and community forest-related characteristics, the logistic regression results indicate that the factors affecting respondent's knowledge of REDD+ goal include respondent's age, economic status of the household, and the proportion of firewood and fodder needs contributed by private land. Moreover, over 95% of the surveyed households were willing to adopt REDD+ in their community forests. These results have implications on design and implementation of future REDD+ policy and projects to generate global climate change benefits from the management of forests at a local level.

1. Introduction

To reduce carbon emissions from forestry sector, the United Nations Framework Convention on Climate Change (UNFCCC) has adopted a policy mechanism: Reducing Emissions from Deforestation and Forest Degradation (REDD); and the conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) (UNFCCC, 2007). Since the Bali Action Plan adopted by Conference of Parties in 2007 (COP13), REDD+ is evolving as a performance-based payment mechanism to sequester and store carbon in forests. Since the conceptualization of REDD in 2007, over 64 countries have been involved in REDD+ readiness activities by 2015 (UN-REDD, 2015) through various bi-and multi-lateral programs, such as UN-REDD and Forest Carbon Partnership Facility of the World Bank. The Paris Agreement, the outcome of COP21, specifically recognized the role of the forestry sector in mitigating climate change and strengthened the funding pledge to implement REDD+, i.e., $100 billion per year until 2020 (UNFCCC, 2015). The successful ratification of the Paris Agreement by parties fulfilling the threshold criteria (at least 55% of parties involved in signing the agreement, that corresponds to at least 55% of the total emissions) within a year indicates promising momentum for REDD+. It potentially helps to develop international REDD+ architecture, increases REDD+ funding, and makes REDD+ a part of the national emissions reduction action plans for developing countries.

Nepal is one of the countries that has implemented REDD+ readiness activities since 2008 and ratified the Paris Agreement. Of 5.96 million ha of forest area (40.36% of country's total area) in Nepal, community forestry occupies about 30.42% of forests, and engages 1.45 million households (DFRS, 2015; DoF, 2015). Community forests (CF) are considered as one of the principal forest types for likely adoption of REDD+ in Nepal. Historically, such forests have been managed for two distinct objectives: environmental conservation and the supply of basic forest products (timber, firewood, fodder etc.) to forest dependent communities (Pandit and Bevilacqua, 2011a). REDD+ complements environmental conservation objective of the community forestry program, i.e. halting deforestation, preventing degradation, conserving and managing forests (Newton et al., 2015). But it could be at odds with forest product supply objective (Poudel, 2014), because sequestering and storing carbon in forests imply compromises on forest product

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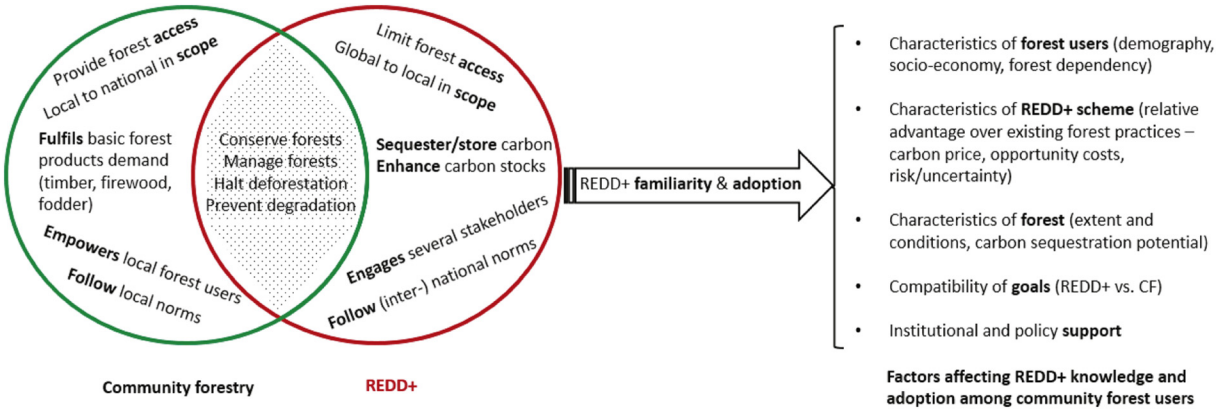
Provide forest access
Local to national in scope
Fulfils basic forest products demand (timber, firewood, fodder)
Empowers local forest users
Follow local norms
Conserve forests
Manage forests
Halt deforestation
Prevent degradation
Limit forest access
Global to local in scope
Sequester/store carbon
Enhance carbon stocks
Engages several stakeholders
Follow (inter-) national norms
Community forestry
REDD+
REDD+ familiarity & adoption
Characteristics of forest users (demography, socio-economy, forest dependency)
Characteristics of REDD+ scheme (relative advantage over existing forest practices – carbon price, opportunity costs, risk/uncertainty)
Characteristics of forest (extent and conditions, carbon sequestration potential)
Compatibility of goals (REDD+ vs. CF)
Institutional and policy support
Factors affecting REDD+ knowledge and adoption among community forest users

Fig. 1. Conceptual model showing commonality (the overlap) and differences (non-overlapping parts of the circles) between community forestry and REDD + along with factors affecting REDD + knowledge and adoption.

removals, affecting forest dependent households for products such as firewood and timber. In addition, community forestry follows local norms, aims to empower local users, and has a local to national scope; while the REDD + follows national/international norms, empowers and engages multiple stakeholders simultaneously, and has a local to global scope. These differences could influence REDD + implementation in community forests. As stated by Komba and Muchapondwa (2017) "… asking households in developing countries to participate in REDD + usually means asking them to compromise the important direct benefits they obtain from forests", which is equally true while introducing REDD + within community forestry practice in Nepal.

The experiences so far from REDD + readiness and piloting schemes are mixed despite the articulation of seven safeguards, including respect to knowledge and rights of indigenous people and local communities and their full and effective participation (UNFCCC, 2010). Some scholars argue that REDD + is a cost-effective climate change mitigation policy (Komba and Muchapondwa, 2017), which provides financial assistance to developing countries and local communities (Angelsen et al., 2012). While others criticize REDD + as a new conservation fad (Koch, 2017; Lund et al., 2017; Redford et al., 2013) that limits access to forests and compromises local people's customary rights (Poudel, 2014; West, 2012) and slows or reverses the promising trend of community-based forest management in developing countries (Phelps et al., 2010). A recent review of the role of community-based forest management to achieve forest carbon benefits and social co-benefits suggests that REDD + is likely to reduce forest degradation but not necessarily the deforestation (Pelletier et al., 2016). Findings like these call for assessment of social and biophysical impacts of REDD + pilot projects implemented in community forests.

Within this background, examining post-piloting responses of households on likely adoption of REDD + and factors that affect their familiarity with REDD + goal provide empirical insights for REDD + implementation and policy making, which is limited in the existing literature (Poudel, 2014). This study aims to contribute to this knowledge gap based on a post-piloting survey of 600 households from two watersheds in central Nepal – Kayarkhola and Ludikhola (Fig. 2). This study deviates from other REDD + studies in two ways: (i) it uses household level data on firewood and fodder demand and (ii) it considers the contribution of private land to fulfill these demand, which truly reflects the level of household dependency on community forests for forest products. The latter is also important because, in most cases, the usual practice of community forestry is to use a quota system to supply these forest products to households without differentiating household needs, leading to potential over- or under-allocation of resources.

As observed by others in examining the factors affecting household dependency on forests (Bastakoti and Davidsen, 2017; Oli and Treueb, 2015; Pandit and Bevilacqua, 2011b; Shrestha and Shrestha, 2017), a number of hypotheses in relation to REDD + adoption by forest users, and respondent's familiarity with REDD + goal are proposed. Firstly, respondent's knowledge on REDD + goal is positively associated with likely adoption of REDD +; secondly, the poor, female and older respondents are less likely to be familiar with REDD + goal; and finally, the greater contribution of private land in supplying forest products (i.e., firewood and fodder) is positively associated with likely adoption of REDD + and respondent's knowledge of REDD + goal.

1.1. Conceptual model and a brief review of adoption and participation literature

Community forestry users in Nepal are economically and socio-demographically heterogeneous with different levels of dependency on forests for forest products. If a new program, such as REDD +, is introduced in community forests, familiarity with program goal and its likely adoption would be affected by a range of factors, including household characteristics, intervention characteristics, and contextual factors, such as compatibility of intervention objectives with existing practices, and the institutional and policy environment (Fig. 1).

Theoretically, the present study is supported by adoption (Schirmer and Bull, 2014; Prokopy et al., 2008) and participation (Oli and Treueb, 2015; Dolisca et al., 2006; Lise, 2000) literature. The adoption literature focuses on factors affecting the adoption of agricultural and forestry practices and commonly argues that adoption of a land management practice depends on personal, social, cultural, and economic factors as well as on the characteristics of the practice itself. For example, the adoption of land conservation practice by land holders depends on relative advantages of the practice (perceived benefits against costs), socio-demographic and farm characteristics, individual and social learning processes, and institutional framework and support, among other things (Bull and Thompson, 2011; Pannell et al., 2006; Prokopy et al., 2008). Similarly, factors affecting the adoption of carbon sequestration and large scale afforestation emphasizes land holders' socio-demographic characteristics and the economic returns from adopted practices as key factors (Schirmer and Bull, 2014; Torres et al., 2010; van Kooten et al., 2002).

The participation literature focuses on factors affecting participation in forestry programs and indicates that several respondent- and household-specific factors affect household behavior (Atmis et al., 2007; Dolisca et al., 2006; Lise, 2000). Respondent- and household-specific factors include education, age, gender, caste, household size, income, technical assistance, condition of the forest and household's dependency on forest (Coulibaly-Lingani et al., 2011; Dolisca et al., 2006; Larson et al., 2015; Lise, 2000; Oli and Treueb, 2015; Subedi and Timilsina, 2016). For example, higher dependency on forest and better

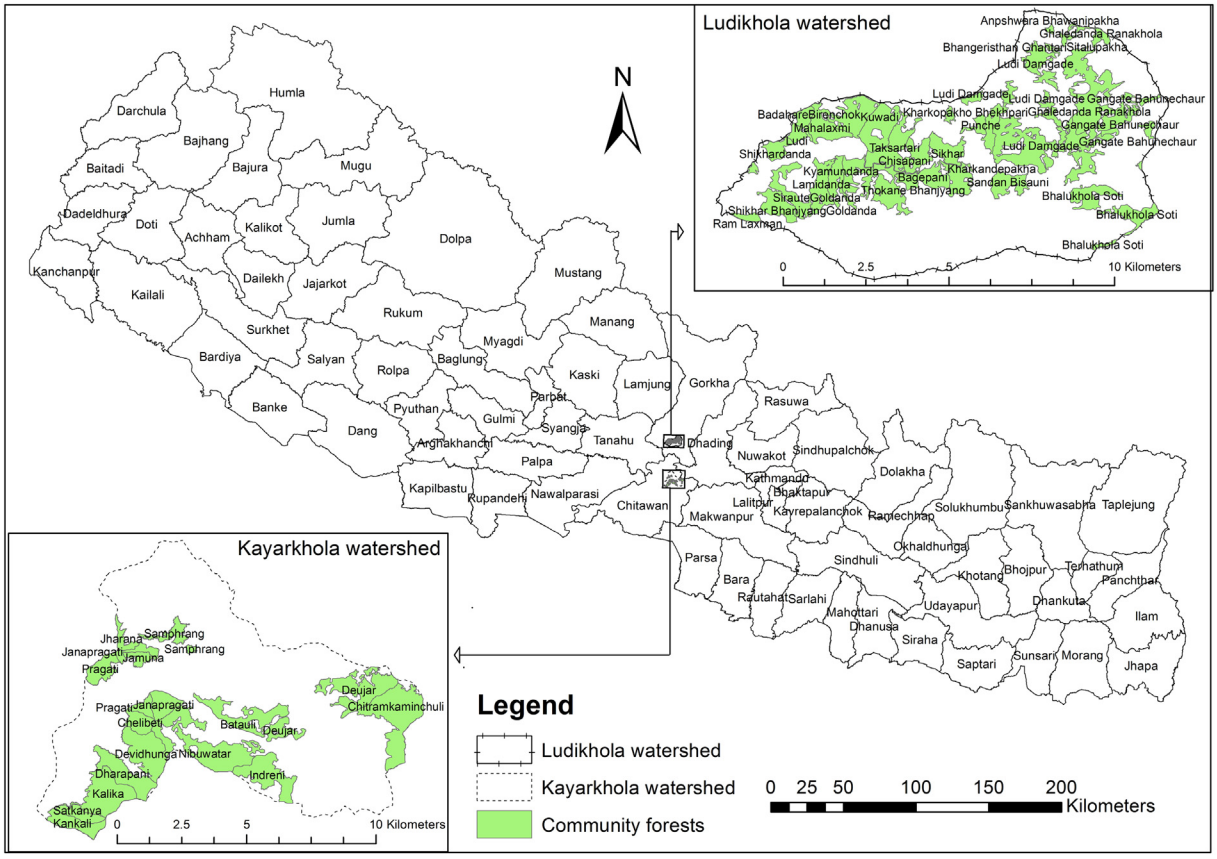

Fig. 2. Maps showing study area, watersheds and community forests.

forest conditions enhance peoples' participation in forest management in India (Lise, 2000). Respondent's gender, household size, income along with land tenure and technical support affect participation in sustainable forest management in Burkina Faso (Coulibaly-Lingani et al., 2011). In addition of respondents' gender, caste, and household size, Oli and Treueb (2015) found that livestock holding and amount of firewood extracted from forest affect household's participation in community forestry activities in Nepal.

Literature on REDD+ readiness, piloting, safeguards, and monitoring, reporting, and verification is rapidly evolving. Even a simple keyword search of three words - REDD, community and Nepal – hits 40 records, and the title word search for 'REDD' and 'Nepal' hits 20 records in Scopus database (as of 30 June 2017). These records have focused on various aspects of REDD+ piloting and implementation in Nepal. But a close examination of the keyword search results with either of the word 'participation' or 'perception' or 'gender' or 'livelihood' or 'impact' or 'implication' on the title of the paper yields only seven records (for details, see Bastakoti and Davidsen, 2017; Khadka et al., 2014; Maraseni et al., 2014; Poudel et al., 2014, 2015; Shrestha and Shrestha, 2017). In a recent study that examined whether REDD+ payment has contributed to households participation in forest governance and management, Shrestha and Shrestha (2017) found that households participation is determined by their socio-economic and community forest's biophysical characteristics rather than economic incentive provided by REDD+ projects. Similarly, Bastakoti and Davidsen (2017) found participating households have positive expectations of REDD+ at varying degrees with a significant concern about likely restrictions on forest products harvesting, suggesting that the livelihood practices of households cannot be fully replaced by monetary benefits of REDD+. In a post-piloting study of nine community forests in the Charnawati watershed of Nepal, Poudel (2014) found that most households were unware of REDD+ implementation and associated benefits; and only a few households have shown motivation for REDD+ as a result of tightened forest use rules. These findings indicate that the literature examining the factors affecting households' knowledge on REDD+ goal and willingness to participate in REDD+ implementation in community forests beyond piloting is at its infancy and just evolving. In a study that examined households' willingness to accept compensation to participate in REDD+ and the factors affecting their participation in Tanzania, Komba and Muchapondwa (2017) found that: a) households that benefited more from forest products demanded higher compensation to participate, and b) the households that spend more time to collect the most important forest product have the higher probability to participate. Thus, there are reasons to believe that households may not be well-aware of REDD+ goal and their preference for REDD+ could be conditional on households' economic and socio-demographic characteristics which directly correlate with their dependency on forests for livelihoods.

1.2. Study area

The study area includes two REDD+ piloted watersheds in central Nepal – Kayarkhola from the inner-terai region and Ludikhola from the hills - comprised of 47 community forests (Fig. 2). These watersheds represent different physiographic zones, species composition, and the socio-economic and demographic characteristics of forest users (Table 1).

REDD+ piloting was implemented under a performance-based payment and benefit sharing mechanism at the community forest level in these watersheds in 2010 for 3 years (ANSAB et al., 2010). Annual carbon sequestration in each community forest was measured and the forest users, i.e. households, were financially rewarded based on a set of criteria devised for the piloting scheme. Payment to each community forest was calculated based on carbon sequestration and other socio-

Table 1
Characteristics of the watersheds.

	Watershed (District)	
Characteristics	Kayarkhola (Chitwan)	Ludikhola (Gorkha)
Altitude, m asl.	245 to 1944	318 to 1714
Physiography	Bhawar/inner-terai	Hill
Latitude (N)	27°40′07.79″ to 27°46′37.15″	27°55′02.85″ to 27°59′43.88″
Longitude (E)	84°33′25.88″ to 84°41′48.85″	84°33′23.13″ to 84°40′41.87″
Average annual temperature, °C	24	23.1
Average annual rainfall, mm	2436	1986
Watershed area, ha	8002	5750
Total community forest area, ha	2382	1888
Number of CF, n	16	31
Total households, n	4163	4110
Population, n	23,223	23,685
User group composition	Chepang & Tamang	Magar, Gurung, Brahmin Chettri
Forest types	*Shorea spp., Terminalia tomentosa, Largestroemia parviflora*	*Shorea spp., Schima wallichii, Castonopsis indica*

economic considerations. Of the total payment, 40% of the payment was based on carbon (24% for stock and 16% enhancement), and the remaining 60% was based on economic and socio-demographic considerations of the forest user group: 20% for poor, 15% for female, 15% for Dalit-ethnic, and 10% for indigenous members (Shrestha et al., 2014). Further details on the nature of the piloting scheme, characteristics of watersheds and community forests, carbon sequestration, and benefit – sharing mechanisms can be found in Shrestha et al. (2014) and Pandit et al. (2017).

2. Methods

2.1. Sampling and data collection

To examine households' forest use pattern, knowledge on REDD+ goal and willingness to adopt REDD+, households were sampled using a stratified-random sampling technique. Households were first stratified by income (poor and less poor) following the absolute poverty line set by the United Nation's (2000), i.e. households with income ≤$1.25/capita/day at 2005 Purchasing Power Parity (or $1/day in 1990 dollars) are considered as poor. Secondly, the households were grouped into three categories based on socio-demography: *Janajati* (indigenous), *Dalit* (marginalized) and *others*. For proportionate representation of households in both economic and socio-demographic strata, a 7% sampling intensity was applied to randomly select 300 sample households from each watershed for household surveys. The households for the survey were identified in sequential steps. First, the forest user group constitution and management plan of each community forest were used in consultation with respective executive committee to develop household rosters. Second, the economic grouping of the member households identified in the constitution was used to develop the sampling strata (economic and socio-demography) from the household rosters. Third, stratified household roster for each stratum (poor, less poor, Janajati, Dalit, and others) in each community forest was then created. Finally, individual households for the survey were identified based on random draw from the stratified rosters or membership lists for each community forest (Appendix A - S1). As a result, a total of 60 poor and 240 less poor sample households were identified for the survey from 16 community forests in Kayarkhola watershed and 72 poor and 228 less poor households from 31 community forests in Ludikhola watershed (see Table 2 for details).

Face-to-face interviews with household heads were conducted during April–June 2013, immediately after piloting scheme was over, using a questionnaire (Appendix A - S2) to collect primary data. Eight qualified survey enumerators (BSc final year students of the Institute of Forestry in Hetauda) were selected for the household surveys and trained on survey procedure including ways to minimize interviewer's bias during the survey.

The two outcome variables analyzed in this study include, responses to survey questions 38 on respondent's familiarity with REDD+ goal (i.e., incentivising forest users to sequester and store carbon in their community forests to mitigate climate change, dummy coded) and 42 on respondent's willingness to participate in REDD+ for extended period of time (dummy coded) (see Appendix A - S2 for these questions). For the first outcome variable, respondents were initially asked whether they were familiar with REDD+ piloting activities in their community forest. If the response was “yes”, then they were asked with a follow-up question whether they know the goal of REDD+. Here again, if the response was "yes", then to confirm whether the respondent really know the goal of the REDD+, a second follow-up question was asked to state the goal of the REDD+. Finally, based on respondents' stated goal of the REDD+, a dummy variable was generated for the first outcome variable, i.e., respondent's knowledge of REDD+ goal.

Following the adoption and participation literature respondent- and household-specific data were collected (e.g., Coulibaly-Lingani et al., 2011; Lise, 2000; Oli and Treueb, 2015). Respondent-specific data includes age, gender, education, and familiarity with REDD+, while the household-specific data includes family size, livestock number by types, land holding by types, forest product demand by types, forest product supply from private lands by types, and willingness to adopt REDD+. Data on types of forest areas that represent forest conditions (dense and sparse), annual carbon sequestration and the total number of user households by community forest and watershed were collected from secondary sources, i.e., forest management plans and the annual carbon monitoring records (ANSAB et al., 2010, 2012). The collected data was analyzed qualitatively, due to limited variations in measured outcome, for REDD+ adoption and quantitatively to understand factors affecting respondents' familiarity with REDD+ goal. The Random Effects Logit Model (xtlogit) was used for statistical analysis using STATA (Ver.14).

2.2. Model

The likelihood of households adopting REDD+ in their community forest can be modelled using discrete choice logit model by defining choice probabilities and deriving them from utility-maximizing behavior of respondents. The behavioral process behind respondent's choice has a functional relationship $y = h(\boldsymbol{x}, \varepsilon)$ between the choice (y) and the observed ($\boldsymbol{x}$) and unobserved (ε) factors (Train, 2003). However, given

Table 2
Sample households by watershed, economic and socio-demographic group.

Watershed	Poor (≤$1.25/capita/day)			Less poor (>$1.25/capita/day)		
	Janajati	Dalit	Others	Janajati	Dalit	Others
Kayarkhola	40	13	7	123	11	106
Ludikhola	29	26	17	121	26	81

relatively homogeneous responses (96% choses to adopt REDD+), a qualitative analysis was done to understand factors affecting behavior or those not-willing to adopt REDD+. Whereas, there is a substantial variations on households' responses to whether the respondent was familiar with REDD+ goal or not. Thus logistic regression modelling is focused on understanding factors affecting respondents' familiarity with REDD+ goal. A respondent, labelled 'n', faces 'j' alternative choices (i.e., j = yes = know REDD+ goal (1) or j = no = do not know REDD + goal (0)). The utility U_{nj} that respondent obtains from alternative 'j' is decomposed into two parts: (i) a representative utility V_{nj} that is known by the researcher up to some parameters; and (ii) an unknown part ε_{nj} that is treated by the researcher as random, i.e. $U_{nj} = V_{nj} + \varepsilon_{nj}$ (Train, 2003).[1] Following McFadden (1974), the (logit choice) probability that respondent 'n' chooses alternative 'i' is given as $P_{ni} = Prob(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \forall j \neq i) = Prob(\varepsilon_{nj} < \varepsilon_{ni} + V_{ni} - V_{nj}, \forall j \neq i)$. If ε_{ni} is considered given, this expression represents the cumulative distribution $F(\varepsilon_{nj})$[1] for each ε_{nj} evaluated at $\varepsilon_{ni} + V_{ni} - V_{nj}$. Since errors ($\varepsilon_s$) are independent, this cumulative distribution over all $j \neq i$ is the product of the individual cumulative distributions $P_{ni}|\varepsilon_{ni} = \prod_{j \neq i} e^{-e^{-(\varepsilon_{ni}+V_{ni}-V_{nj})}}$. Since ε_{ni} is not given, so the choice probability is the integral of $P_{ni}|\varepsilon_{ni}$ over all values of ε_{ni} weighted by its density as $P_{ni} = \int (\prod_{j \neq i} e^{-e^{-(\varepsilon_{ni}+V_{ni}-V_{nj})}}) e^{-\varepsilon_{ni}} e^{-e^{-\varepsilon_{ni}}} d\varepsilon_{ni}$ (for details see Train, 2003). With algebraic manipulation, the integral results in a closed-form expression $P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}$, which is the logit choice probability. The observed part of the utility, V_{nj}, is specified to be linear in parameters, i.e., $V_{nj} = \beta' x_{nj}$, where x_{nj} is a vector of observed variables relating to alternative 'j'. With this specification, the logit probability for choice 'i' becomes $P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}}$ (Train, 2003).

Based on the above description of the behavioral model, a household or respondent chooses an alternative choice that maximizes household utility, and the choice depends on some observed and unobserved factors (ε_1 for choice = 1 and ε_0 for choice = 0). Following the conceptual model (Fig. 1), the observed factors that affect the choice probability include respondent- and household-specific attributes (e.g., economic and socio-demographic characteristics), characteristics of the REDD+ scheme, and characteristics of the community forest. Following Train (2003), the probability that respondent chooses to indicate familiarity with REDD+ goal can be expressed as $P_{n1} = \frac{e^{\beta' x_{n1}}}{e^{\beta' x_{n1}} + e^{\beta' x_{n0}}}$ and the probability that respondent chooses to indicate unfamiliarity with REDD+ goals as $P_{n0} = \frac{e^{\beta' x_{n0}}}{e^{\beta' x_{n0}} + e^{\beta' x_{n1}}}$. Dividing numerator and denominator by $e^{\beta' x_{n1}}$, the choice probability for familiarity with REDD+ goal becomes $P_{n1} = \frac{1}{1 + e^{\beta' x_{n0} - \beta' x_{n1}}}$; with representative utility it can be written as $P_{n1} = \frac{1}{1 + e^{V_{n0} - V_{n1}}}$.[2] If only the observed variables enter into the model and their coefficients are normalized to zero for familiarity with REDD+ goal ($y = 1$), then the probability for being familiar with REDD+ goal is $P_{n1} = \frac{1}{1 + e^{\beta' x_n}}$. Following Long and Freese (2006), the logit model that represents the likelihood of respondents being familiar with REDD+ goal can be expressed in the following form:

$$Logit\,[P(y_n = 1 \mid \boldsymbol{x}_n)] = Log\left[\frac{P(y_n = 1 \mid \boldsymbol{x}_n)}{1 - P(y_n = 1 \mid \boldsymbol{x}_n)}\right] = \beta_0 + \beta' \boldsymbol{x}_n \quad (1)$$

where, y_n is the binary response variable indicating familiarity with REDD+ goal by n[th] respondent; $\boldsymbol{x}$ is the vector of respondent, household and community forest-related characteristics; and $\boldsymbol{\beta}$ is the vector of parameter coefficients. When linked to the characteristics of the respondent, household and the community forest, the logit model takes the form in Eq. (2). Conceptually important model variables, such as respondent's education and caste, were included in the original logit model, but they appear to be insignificant across different model specifications. Similarly, carbon price, institutional and policy support as identified in Fig. 1 are important variables to determine respondent's knowledge of REDD+ goal, but these variables are invariant across respondents or households; thus, excluded from the model.

$$Logit\,[P(KnowREDD_n^+ = 1 \mid \boldsymbol{x}_n)] = \beta_0 + \beta_1 EconGr_n + \beta_2 Age_n + \beta_3 Gend_n + \beta_4 \%FWsPL_n + \beta_5 \%FDsPL_n + \beta_6 ADF_n \quad (2)$$

where $KnowREDD_n{}^+$ represents n[th] respondent's familiarity with REDD + goal (0 = no and 1 = yes), *EconGr* represents whether the respondent belongs to a member of the poor (0) or less-poor (1) group; *Age* and *Gend* refer to respondent's age and gender (0 = female and 1 = male); %*FWsPL* and %*FDsPL* represent the proportion of household's firewood and fodder demand fulfilled from private land, respectively; and *ADF* represents the area of community forest categorized as dense forest, representing a proxy for forest condition and carbon sequestration potential. The firewood and fodder supplied from community forests to households are generally limited by quota per household (either in terms of volume or number of collection days by a certain number of collectors). Hence, we used the proportion of firewood and fodder demand that is fulfilled from private land, which truly reflects the nature of household's dependency on community forests for these forest products.

In Eq. (2), for $\beta > 0$, $P(KnowREDD^+ = 1)$ increases as x increases and for $\beta < 0$, $P(KnowREDD^+ = 1)$ decreases as x increases. Consistent with adoption and participation literature (e.g., Coulibaly-Lingani et al., 2011; Lise, 2000; Oli and Treueb, 2015) and the hypotheses presented earlier, as a priori, it is hypothesized that *EconGr*, %*FWsPL*, %*FDsPL* and *ADF* positively affect the likelihood of respondents' familiarity with $REDD^+$ goal, while the respondents' age and gender (female) would negatively affect respondents familiarity with $REDD^+$ goal.

3. Results and discussion

3.1. Descriptive statistics

Out of 300 observations from each watershed, 259 and 252 observations were valid for further analysis in Kayarkhola and Ludikhola watershed, respectively. A few observations (41 from Kayarkhola and 48 from Ludikhola) were excluded from the analysis for two reasons: underage respondents (<18 years) and undefined firewood or the fodder demand[3]. Descriptive statistics for the entire sample (n = 511) are presented in Table 3. At the watershed level, on average, over 95% of the respondents were likely to adopt REDD+, whereas only about two-thirds of the respondents were knowledgeable of REDD+ goal (Table 3). About a quarter of respondents were considered economically poor and about two-in-five respondents were female. The average age of respondents in Kayarkhola watershed was about 43 years, which was about 5-year younger than the age of respondents in Ludikhola watershed.

On average, household's annual firewood demand was lower in Kayarkhola watershed (2051 kg) compared to Ludikhola (2426 kg); however, private land contributed much less to household's firewood

[1] The logit model is obtained by assuming that ε_{nj} is independently, identically distributed (iid) extreme value. The density for each unobserved component of utility is $f(\varepsilon_{nj}) = \exp(-\varepsilon_{nj}).\exp(-\exp(-\varepsilon_{nj}))$, and the cumulative distribution is $F(\varepsilon_{nj}) = \exp(-\exp(-\varepsilon_{nj}))$ (Train, 2003).

[2] Similar to the first alternative, dividing numerator and denominator of $P_{n0} = \frac{e^{\beta' x_{n0}}}{e^{\beta' x_{n0}} + e^{\beta' x_{n1}}}$ by $e^{\beta' x_{n0}}$, the choice probability for being unfamiliar with REDD+ goal can be expressed as $P_{n0} = \frac{1}{1 + e^{\beta' x_{n1} - \beta' x_{n0}}}$; and with representative utility it can be written as $P_{n0} = \frac{1}{1 + e^{V_{n1} - V_{n0}}}$.

[3] In Kayarkhola watershed, the excluded observations include 7 < 18 years of respondent's age, 9 with no firewood demand and 25 with no fodder demand. Similarly, the 48 in Ludikhola watershed include 3 < 18 years of respondent's age, 15 with no firewood demand and 30 with no fodder demand.

Table 3
Descriptive statistics.

Variables, coding and unit	Aggregate				Kayarkhola watershed				Ludikhola watershed			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Willing to adopt REDD+ (0 = no, 1 = yes)	0.96	0.18	0	1	0.98	0.14	0	1	0.95	0.22	0	1
Knowledge on REDD+ goal (KnowREDD+: 0 = no, 1 = yes)	0.66	0.47	0	1	0.64	0.48	0	1	0.69	0.46	0	1
Economic status (EconGr: 0 = poor, 1 = less poor)	0.77	0.42	0	1	0.79	0.41	0	1	0.75	0.44	0	1
Education (0 < high school, 1 ≥ high school (SLC))	0.12	0.32	0	1	0.13	0.34	0	1	0.10	0.30	0	1
Age of respondent (years)	45.86	13.94	18	85	43.75	14.57	18	85	48.03	12.93	18	80
Gender (Gend: 0 = female, 1 = male)	0.59	0.49	0	1	0.59	0.49	0	1	0.59	0.49	0	1
Firewood demand/household (kg/yr)	2235.71	2218.84	50	18,000	2051.06	1820.21	150	10,000	2425.50	2554.70	50	18,000
Amount of firewood supplied to household from private land/source (kg/yr)	1059.59	1746.35	0	17,625	485.91	892.74	0	6000	1649.21	2165.37	0	17,625
% of firewood demand supplied from private land/source (%FWsPL: kg/yr)	0.46	0.41	0	1	0.27	0.35	0	1	0.66	0.38	0	1
Fodder demand/household (kg/yr)	6021.06	5147.30	120	28,000	7314.98	5167.61	400	28,000	4691.19	4783.47	120	21,600
Amount of fodder collected from private land/source (kg/yr)	3531.19	4083.83	0	21,600	3377.14	3865.62	0	18,000	3689.52	4298.54	0	21,600
% of fodder demand supplied from private land/source (%FDsPL: kg/yr)	0.60	0.38	0	1	0.45	0.38	0	1	0.76	0.33	0	1
Community forest area (ha)	115.05	77.96	5.24	329.18	123.87	70.72	34.53	329.18	105.98	83.93	5.24	270.71
Number of user households (n)	593.36	713.27	30	1922	938.66	855.98	32	1922	238.48	176.38	30	522
Area of dense forest (ADF, ha)	96.50	67.02	0.33	315.21	103.24	64.22	10.86	315.21	89.58	69.22	0.33	221.44
Amount of carbon sequestered in the community forest (tC/yr)	335.18	279.40	21.27	1109.63	238.13	141.32	43.49	685.13	434.93	344.07	21.27	1109.63
Area of rain fed land (m^2)	2087.22	3427.94	0	33,863	775.78	2732.14	0	33,863	3435.09	3550.30	0	20,840
Number of observations (N)	511				259				252			

demand in Kayarkhola (27%) than in Ludikhola (66%). On the other hand, annual fodder demand was higher in Kayarkhola (7315 kg) than in Ludikhola (4691 kg). Private land contributed only about 45% of fodder demand in Kayarkhola compared to 76% in Ludikhola watershed. On average, number of users, area of community forests, and the area of dense forests were higher in Kayarkhola watershed, but the amount of carbon sequestered in forests and the area of rain fed land per household were much higher in Ludikhola watershed (Table 3).

3.2. Characteristics of respondents and households: REDD+ adopters vs. non-adopters

Given the survey was conducted after the completion of REDD+ piloting, we asked respondents whether they are likely to adopt REDD+ in their community forests. Most respondents (>95%) indicated that they are willing to adopt REDD+ if it is being implemented in the future (Table 4). Even though the portion of respondents or households not-willing to adopt REDD+ was small, understanding their characteristics is important for successful implementation of REDD+. The data reveals that less educated, older and male respondents are not willing to adopt REDD+ (Table 4). By comparison, these respondents belong to households that are considered as poor and demand higher amount of firewood and fodder for household consumption (Table 4). These households also have higher amount of rainfed land, which contributes to their higher proportion of firewood and fodder supply from private lands.

3.3. Association between respondent's knowledge of REDD+ goal and other covariates

Table 5 presents the results of association between respondent's knowledge of REDD+ goal and other characteristics in both the aggregate and watershed-specific samples. In aggregate, there is a significant association between respondent's knowledge on REDD+ goal

Table 4
Characteristics of REDD+ adopters and non-adopters.

Variables	REDD+ Adopters				REDD+ Non-adopters			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Knowledge about REDD+ (0 = no, 1 = yes)	0.667	0.472	0	1	0.500	0.514	0	1
Economic status (0 = poor, 1 = less poor)	0.773	0.419	0	1	0.389	0.502	0	1
Education (0 ≤ high school, 1 ≥ high school (SLC))	0.122	0.327	0	1	0	0	0	0
Age of respondent (years)	45.65	13.90	18	85	51.67	14	22	75
Gender (0 = female, 1 = male)	0.584	0.493	0	1	0.722	0.461	0	1
Firewood demand/household (kg/yr)	2196	2173	50	18,000	3313	3134	375	10,000
Amount of firewood supplied to household from private land (kg/yr)	1022	1692	0	17,625	2100	2722	0	9000
% of firewood demand supplied from private land (kg/yr)	0.459	0.411	0	1	0.524	0.471	0	1
Fodder demand/household (kg/yr)	6021	5165	120	28,000	6011	4767	800	15,000
Amount of fodder collected from private land/source (kg/yr)	3497	4072	0	21,600	4467	4404	0	14,400
% of fodder demand supplied from private land/source (kg/yr)	0.597	0.384	0	1	0.717	0.397	0	1
Community forest area (ha)	115.103	78.106	5.240	329.180	113.643	75.909	17.440	270.710
Number of user households (n)	599	718	30	1922	441	567	77	1922
Area of dense forest (ha)	96.599	67.211	0.330	315.210	93.806	63.157	5.750	221.440
Amount of carbon sequestered in the community forest (tC/yr)	332.309	277.237	21.268	1109.625	413.817	332.808	59.605	1109.625
Area of rainfed land (m^2)	2033	3166	0	20,840	3580	7742	0	33,863
Number of observations	493				18			

Table 5
Chi-square test results on association between respondents' knowledge of REDD+ goal and other covariates.

Variable	Know REDD+ goal (no or yes)		
	Aggregate	Kayarkhola	Ludikhola
Adopt REDD+ (no or yes)	2.172	0.030	3.224*
Economic group (poor or less poor)	0.004	2.456	2.371
Caste (Janajati or Dalit or others)	7.150**	15.675***	1.757
Gender (female or male)	1.818	0.832	0.988
Education (> SLC[a] or < SLC)	0.240	4.691**	3.433*
Collect firewood from private land (no or yes)	1.222	0.497	0.084
Need additional firewood than CF provides (no or yes)	1.865	4.169**	0.802
District (Gorkha or Chitwan)	1.394	–	–
Land (no or yes)	0.722	1.496	0.029
Livestock (no or yes)	0.001	1.148	2.199
Compromised forest product collection due to REDD+	29.416***	35.044***	3.183*
Got incentive from REDD+ (no or yes)	6.752***	28.683***	3.370*
Number of observations	511	259	252

The figures in the table are Pearson Chi-square statistics. ***, ** and * represent 1%, 5%, and 10% level of significance, respectively.
[a] School Leaving Certificate (SLC) is the final exam of the 10th grade.

and their caste and any compromises on forest product collection or financial gains they have experienced through REDD+ piloting. At the watershed level, such associations exist except the one between caste and knowledge of REDD+ goal in Ludikhola. Education of respondent is associated with knowledge of REDD+ goal in both watersheds; while necessity of additional firewood than what CF provides and willingness to adopt REDD+ in community forests are associated with respondents' knowledge of REDD+ goal only in Kayarkhola and Ludikhola watershed, respectively.

3.4. Logistic regression results

The logistic regression results provide interesting evidence on factors and their direction and magnitude of influence on likelihood of respondents and households being knowledgeable of REDD+ goal (Table 6). The probability of respondents being knowledgeable of REDD + goal increases significantly with an increase in their economic status from poor to less poor and with increased proportion of firewood demand supplied from private land, whereas such probability decreases significantly with increase in respondent's age and increased proportion of fodder demand supplied from private land.

Table 6
Factors affecting household-head or respondent's knowledge on REDD+ goal (binary response; 0 = no, 1 = yes).

Variables	Coefficient estimate	Standard error
Economic status (0 = poor, 1 = less poor)	0.563*	0.332
Age (years)	−0.019**	0.009
Gender (0 = female, 1 = male)	0.061	0.260
Proportion of firewood demand supplied from private land (kg/yr)	0.774**	0.299
Proportion of fodder demand supplied from private land (kg/yr)	−1.073***	0.360
Area of dense forest per household (ha)	0.107	0.460
Watershed (0 = Kayarkhola, 1 = Ludikhola)	−0.693	0.634
Constant	3.061**	0.911
Number of observations (N)	511	
Wald Chi^2 test statistics	26.05***	
Log pseudolikelihood	−279.565	

Note: ***, ** and * represent 1%, 5% and 10% significance levels.

Empirical estimate suggests that, holding other variables constant, being a less-poor household (compared to a poor household) increases the odds of being knowledgeable of REDD+ goal by $e^{0.563} = 1.76$ times (i.e. 76% increase). Similarly, a 1% increase in the proportion of household's firewood demand fulfilled from private land increases the odds of being knowledgeable of REDD+ goal by $e^{0.774} = 2.17$ times (i.e., 117% increase), whereas same level of increase in the proportion of household's fodder demand fulfilled from private land decreases the estimated odds of respondents' being knowledgeable of REDD+ goal by $e^{-1.072} = 0.34$ times (i.e., $\approx 1/2.94$ by a factor of 2.94). Respondent's age is negatively and significantly correlated with likelihood of being knowledgeable of REDD+ goal, i.e., a one year increase in respondent's age decreases the odds of such likelihood by $e^{-0.018} = 0.98$ times (i.e., $\approx 1/1.02$ by a factor of 1.02). Interestingly, respondent's gender and the area of dense forest have no significant effect on likelihood of respondents being knowledgeable of REDD+ goal.

The direct comparison of the factors affecting likelihood of respondents being knowledgeable of REDD+ goal with other studies from the same area is not possible as past studies either lack household-level data for the entire watersheds or have used specific community forests within a particular watershed (e.g., Poudel et al., 2015). However, the findings of such local studies on various other aspects of REDD+ as well as relevant studies from other parts of the world would provide a relevant benchmark to compare and contrast the present findings.

The current finding of less-poor households are more likely to be knowledgeable of REDD+ goal could be the outcome of the benefit sharing mechanism adopted in the piloting sites. It is plausible that less-poor households are less dependent on forest products and favor carbon sequestration and storage in the forests by comparison (with poor households), thereby would be more familiar with REDD+ goal. Saito-Jensen et al. (2014) indicated that the benefit sharing mechanism adopted in the piloting sites created social tensions as it emphasized economic and socio-demographic considerations of users (60%) over carbon sequestration and storage (40%). Poudel et al. (2015) in Ludikhola watershed found that despite favoring women and *Dalits* (marginalized caste) in a benefit sharing mechanism, not everyone experienced the anticipated benefits of REDD+. On level of respondent's education, only a small fraction of the respondents (61/511 = 12%) were high school graduates (i.e., >10th grade) and the level of education is significantly associated with respondent's knowledge of REDD + goal at the watershed level but not on the entire sample (Table 5)[4].

The finding on inverse relationship between age and respondent being knowledgeable of REDD+ goal is in accordance to the finding reported in forest management or REDD+ specific participation literature. For example, Komba and Muchapondwa (2017) in Tanzania found that an increased age of respondent is associated with decreased willingness to participate in REDD+.

The finding on increased proportion of forest product demand fulfilled from private land increases (for firewood) and decreases (for fodder) the likelihood of a respondent being knowledgeable of REDD+ goal is in line with some of the earlier findings (Oli and Treueb, 2015; Poudel et al., 2015; Shrestha et al., 2014). For example, Shrestha et al. (2014) notes that forest dependent communities are interested in implementing REDD+ only in condition of maintaining access to forest resources. The increase in probability of respondent being knowledgeable of REDD+ goal with an increase in %FWsPL is plausible as it relates to reduced supply of firewood from community forests and thereby increased sequestration and storage of carbon in the CF, leading to financial benefits to households. However, increase in probability of respondent being knowledgeable of REDD+ goal with an increase in % FDsPL is unexpected. But from carbon sequestration point of view

[4] Level of education and economic status were modelled as dummy variables and there is high collinearity between the two. Hence education, although theoretically appealing, has been omitted from the regression model.

limiting firewood extraction from CF is more important for households than fodder as the carbon content in the former is higher.

Local studies in Nepal on household's participation in community forestry, forest product demand and REDD+ provide mixed evidence. In a choice experiments study of households' preferences for REDD+ contract attributes in community forests, Dissanayake et al. (2015) found that households care about the fairness of access to forest resources and the restrictions on grazing and firewood use. Similar finding on increased restrictions on forest product harvesting from community forests under REDD+ projects was echoed by Bastakoti and Davidsen (2017). However, Shrestha and Shrestha (2017) noted that households' participation in community forest management is not determined by the economic incentive provided by REDD+ rather by socio-demography of the participating households and biophysical characteristics of the community forests. These findings suggest that there are potential trade-offs between households forest product needs and access to community forests and their preference for REDD+ project (Rana et al., 2017).

Beyond Nepal, in a pioneering study that analysed three early cases of a landscape approach to REDD+ development and implementation in Brazil, Ecuador, and Mexico, Bastos Lima et al. (2017) found that the national and international political commitments are preconditions for transformative REDD+ interventions, signaling that integrated policy provision is a likely determinant of a landscape (e.g. watershed) approach to REDD+ implementation. In Cambodia, an analysis of media attention to policy suggested that how REDD+ message is being framed in the media is important to gain attention from policy makers and the public on REDD+ policy, opportunity and impact (Nhem et al., 2017).

In light of the above discussion, the current findings have implications on future REDD+ project design and implementation. The findings indicate that household or respondent's being knowledgeable of REDD+ goal while piloting REDD+ in community forests was contextual, signaling a need to balance the primary objectives of community forestry program and REDD+. For instance, there are seemingly opposite results of proportional contribution of firewood and fodder supplied from private lands to households on likelihood of respondent being knowledgeable of REDD+ goal. This limitation suggests that government and other stakeholders should make local users aware of the REDD+ project goal and fully engage them in REDD+ project design and implementation (Gilani et al., 2017). In particular, the elderly and poor households should be made aware of the opportunities and risks of REDD+ projects for their successful implementation in the long run.

4. Conclusion

This paper examines the profile of likely adopters and non-adopters of REDD+ and the factors affecting the likelihood of respondents being knowledgeable of REDD+ goal in two watersheds of central Nepal based on household surveys. An overwhelming majority of respondents (>95%) were willing to adopt REDD+ if it becomes a regular program. However, only about 2/3rd (66%) of the respondents were fully aware of the REDD+ goal. The implication of these results is that all participating households or communities need to be fully aware of REDD+ program and its goal before adopting REDD+ to avoid implementation failures.

The factors affecting respondent's knowledge of REDD+ goal include economic status of the household, age of the respondent, and the extent of households' firewood and fodder demand fulfilled from private land. As hypothesized earlier, better economic status of the household and higher contribution of firewood demand from private land increase the likelihood of the respondent being knowledgeable of REDD+ goal. On the contrary, older respondents and households with higher contribution of fodder from private land decrease such likelihood. Given the role of economic, demographic and forest product-specific factors affecting familiarity of REDD+, particularly its goal, at the household level, these factors should be carefully considered in designing REDD+ projects to facilitate their successful implementation to achieve project goals. Such a thoughtful design would maintain a balance between project objectives and forest users' composition, needs, and aspirations for effective implementation of REDD+ in the future, not only in Nepal but in other parts of the world where high forest dependency exists among socio-economically and demographically heterogeneous population.

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Appendix A. Supplementary data

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